



JACOBS ENGINEERING GROUP INC
ENVIRONMENTAL SYSTEMS DIVISION

SITE	<u>Elliott Shooting Park</u>
ID#	<u>MOD 980968333</u>
BREAK	<u>21</u>
OTHER	<u>075B</u>
	<u>11.5.87</u>

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November 5 1987

Mr David Crawford
US Environmental Protection Agency
Region VII Superfund Branch
726 Minnesota Ave
Kansas City KS 66101


**Re Final Potential Contaminant Migration
and Groundwater Use Report**

Dear Mr Crawford

Please find enclosed the Final Potential Contaminant Migration and Groundwater Use Report for the Elliott Shooting Park Site and surrounding area

Please contact Jill Biesma Glenn Curtis or me at 492 9218 should you have any questions

Sincerely


Gary E. Parker
Region VII Manager

GEP:css

Enclosures

cc Glenn Curtis
Jill Biesma

40165762



SUPERFUND RECORDS

Jim Biesma / Glenn Curtis, Jacobs Eng

Re Elliott Shooting Park

I have received your Final Potential ~~Ground~~ Contaminant Migration & Groundwater Use Report, dated 11/5/87 ✓
found the report acceptable as a final report

cc John Chen SCOM
Craig Smith SCOM

Dave Cragford 11/10/87
EPA / SCOM

ENVIRONMENTAL PROTECTION AGENCY
TECHNICAL ENFORCEMENT SUPPORT
AT
HAZARDOUS WASTE SITES

TES IV
CONTRACT #68-01-7351
WORK ASSIGNMENT #194

ELLIOTT SHOOTING PARK SITE
POTENTIAL CONTAMINANT MIGRATION
AND GROUNDWATER USE
FINAL REPORT
EPA REGION VII

JACOBS ENGINEERING GROUP, INC
PROJECT NUMBER 05-B194-00

NOVEMBER 5, 1987

ELLIOTT SHOOTING PARK SITE
POTENTIAL CONTAMINANT MIGRATION AND GROUNDWATER USE REPORT

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1 0 INTRODUCTION

The Elliott Shooting Park site and adjacent east property are contaminated with lead as a result of trap and skeet shooting at and in the area of the park from 1887 to 1983. Laboratory results of surface soil samples collected from these properties indicated total lead concentrations from 48.1 parts per million (ppm) to 5900 ppm.

Due to the site's location and the toxic nature of lead, a removal was mandated under CERCLA Section 106 Administrative Order. In 1986, removal actions were initiated by one of the Potentially Responsible Parties, Boatmen's First National Bank of Kansas City (1).

This report has been prepared to assist the U.S. EPA in assessing the potential for groundwater contamination and human consumption of groundwater in the vicinity of the site. The objective of this study is to determine the likelihood for contamination of the local aquifer systems by lead from the Elliott Shooting Park Site and the probability of human consumption of lead-contaminated groundwater through use of private wells in the vicinity of the site.

This report is organized into seven sections. The site description and history are presented in Section 2.0. This is followed by a brief discussion on the characteristics of lead related to contaminant migration. In Section 4.0, regional and local environmental conditions and their influence on contaminant migration are discussed. The results of the private groundwater use investigations are presented in Section 5.0. An assessment of potential contaminant migration and human consumption of contaminated groundwater in the vicinity of the site is presented in Section 6.0. References, which are numbered sequentially in parentheses within the text, are listed in Section 7.0.

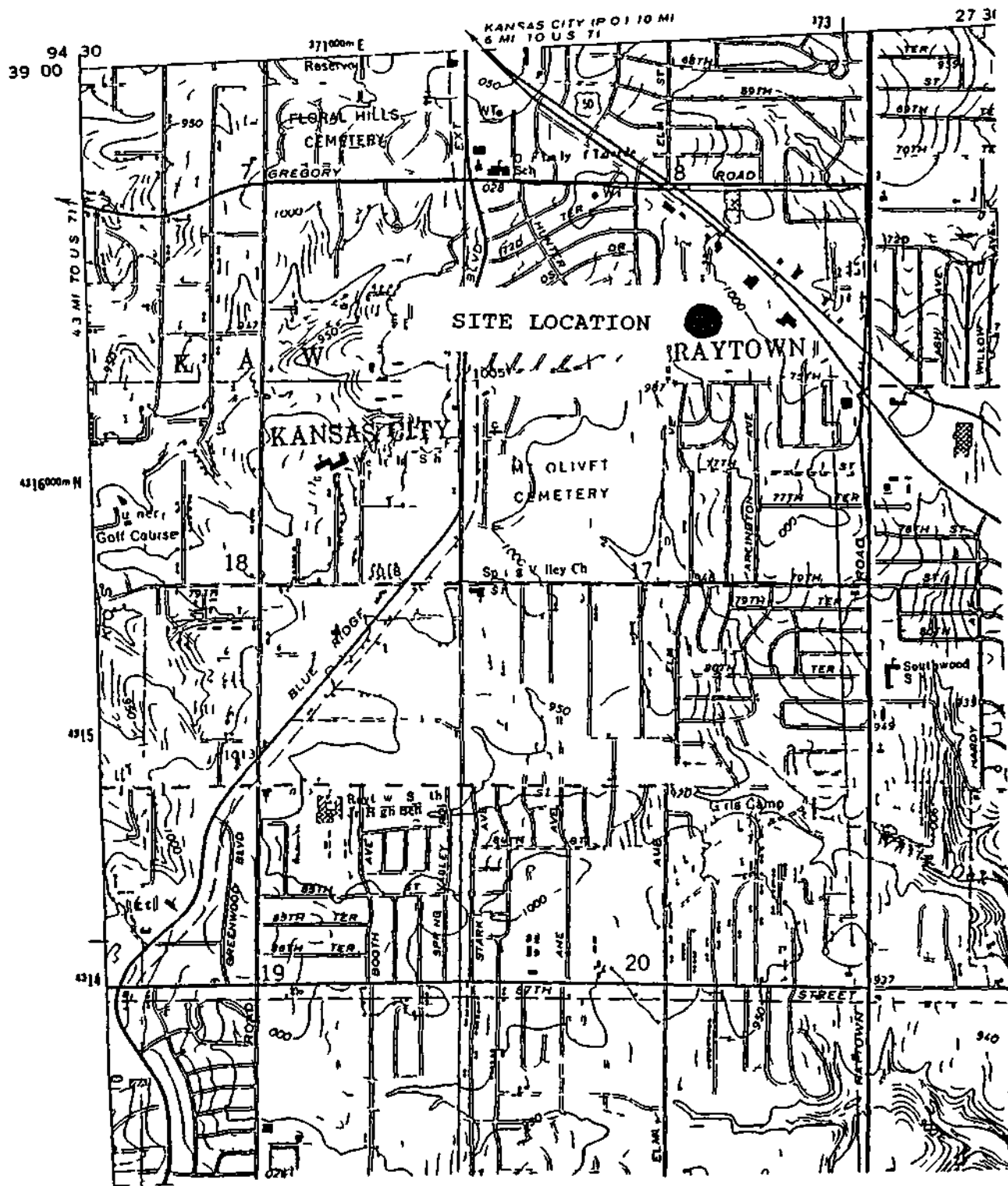
2 0 SITE DESCRIPTION AND HISTORY

Elliott Shooting Park is located at 9530 East 75th Street in Raytown, Missouri as shown on Figure 1. The site covers approximately 31 acres and is surrounded by residential and commercial properties.

The site and potential areas in the general vicinity were operated as a trap and skeet shooting target range for the recreational use of shotguns from 1887 until its foreclosure in April 1983 by Boatmen's First National Bank of Kansas City. Site activities resulted in the deposition and accumulation of lead shot on the ground surface. During its operation, the site was periodically "mined" by a company which removed the shot from the soil and recycled the lead. The facility has not been mined since 1982. In 1984, soil samples were collected at the facility and analyzed for lead. Laboratory results indicated total lead concentrations from 48.1 ppm to 5900 ppm.

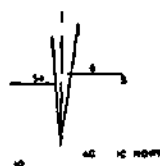
Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, the U. S. EPA issued a Section 106 Administrative Order to the Boatmen's First National Bank of Kansas City, Missouri in January 1986. The Order required Boatmen's First National Bank of Kansas City, Missouri to remove the extensive lead contamination on the 31 acre site.

In 1986, removal actions were initiated by Boatmen's First National Bank of Kansas City. Actions performed to date have involved the removal and washing of contaminated surface soils from a portion of the site. Lead has been separated from the soil by the use of a wet separation process and gravitational means, concentrated, and removed for recycling. The washed soils have been stockpiled for future removal to an approved landfill. The wash water has been contained in a holding pond for potential recycling. The pond water and accumulated sediments are to be managed as part of the removal action. Removal actions were anticipated to be completed the fall of 1987 (1). These efforts may be continued into the spring of 1988 due to difficulties experienced in the removal process and discovery of additional areas of contamination.



Reference

7 5 Minute Series Topographic Map Lee s
Summit Quadrangle Jackson County Missouri
United States Geologic Survey 1975



SCALE

1000 0 1000 2000
FEET

Figure 1 Site Location

3 0 CHARACTERISTICS OF LEAD RELATED TO CONTAMINANT MIGRATION

The elemental form of lead has a low volatility, is relatively insoluble, and is biotransformed and accumulated by organisms. Lead characteristically attaches to soil particles and can be relocated by wind. Contaminated soils are also susceptible to being physically relocated by surface runoff. The efficient fixation of lead by most soils greatly limits the transfer of lead to aquatic systems and also inhibits adsorption of lead by plants.

Depending on the compound, lead can be very mobile in the environment, especially the organic species. Lead can be mobilized in water and is leachable depending on such factors as metal species, pH of groundwater and soil, and soil texture and chemistry. The presence of organic matter, carbonates, and phosphates in the soil promotes soil absorption of lead, whereas acidic soil conditions promote contaminant leaching (2).

4 0 ENVIRONMENTAL SETTING

4 1 INTRODUCTORY SUMMARY

The Elliott Shooting Park is located on the Osage Plains of the North American Central Lowland Physiographic Province. These Plains exhibit overall low relief, however, local escarpments (steep slopes and cliffs formed by erosion and faulting) are present and generally consist of 10 to 30 feet of erosion-resistant limestone.

The surficial material in the vicinity of the site consists of a thin layer of loess over residuum (soil which is formed in place). The loess consists primarily of silt-sized particles which were picked up by wind from glacial outwash plains and deposited downwind. The residuum is derived from parent bedrock of Pennsylvanian age, including thick sandstones and limestones and thin cyclic deposits of sandstone, shale, coal, limestone, siltstone, and clay.

The residuum soils consist of silt loam and silty clay loam with varying amounts of clay and organic matter to a depth of five to six feet. The permeability of these soils are generally moderate. However, these soils frequently develop a clay pan subsoil of low permeability because they are highly erodible. In addition, urbanization of the area surrounding the site has resulted in the construction of roads, parking lots and buildings, all of impermeable materials which inhibit infiltration of precipitation.

The presence of organic matter in the residuum soils promotes soil absorption of lead and thus restricts contaminant migration. The moderate to low permeabilities of these soils and the impermeable surfaces resulting from the urbanization of the area also inhibit contaminant migration.

The bedrock geology in the vicinity of the Elliott Shooting Park consists of the Pleasanton and Kansas City Groups of the Missourian Series and the Cherokee and Marmaton Group of the Desmoinesian Series.

The Kansas City Group ranges from 120 to 135 feet in thickness below the residuum and consists of ledge forming limestones and intervening shale formations. The Pleasanton Group, which is located below the Kansas City Group, ranges from 20 to 150 feet in thickness and consists of silty shale and sandstone formations.

A channel-fill sandstone, referred to as the Warrensburg Sand, is located within the Pleasanton Group in the vicinity of the site. Although the Warrensburg Sand is a laterally restricted sinuous deposit, it appears to be the only formation within the Pleasanton Group having a thickness adequate to be classified as a potential aquifer. The quality of groundwater within this formation is anticipated to be poor due to high concentrations of total dissolved solids and chlorides.

The Pleasanton Group rests respectively on the Des Moines Series Groups, the Marmaton and the Cherokee. The Marmaton Group consists of a succession of shale, limestone, clay and coal beds. Compared with the Cherokee Group below, the Marmaton contains more limestone units which are also thicker and more persistent. Within the upper portion of the Cherokee Group is the Lagonda formation. The average depth of this formation is 425 feet below the ground surface.

The Lagonda formation is composed of shale, siltstone sandstone and, locally, consists almost entirely of sandstone. The thickness of the Lagonda formation varies between 35 and 95 feet. This formation is the shallowest potential aquifer of widespread significance in the vicinity of the site. Because of the subsurface conditions at depth, the quality of groundwater within the Lagonda formation is expected to be below the chemical drinking water standards of the U. S. Public Health Service.

The environmental setting of the site, which was outlined above, is described in greater detail in the following sections. The impact of the environmental setting on contaminant migration is discussed in Section 6.0.

4.2 GEOLOGY

The geology of central western Missouri and the geology of the Raytown area are outlined in the following sections.

4 2 1 Regional Geology

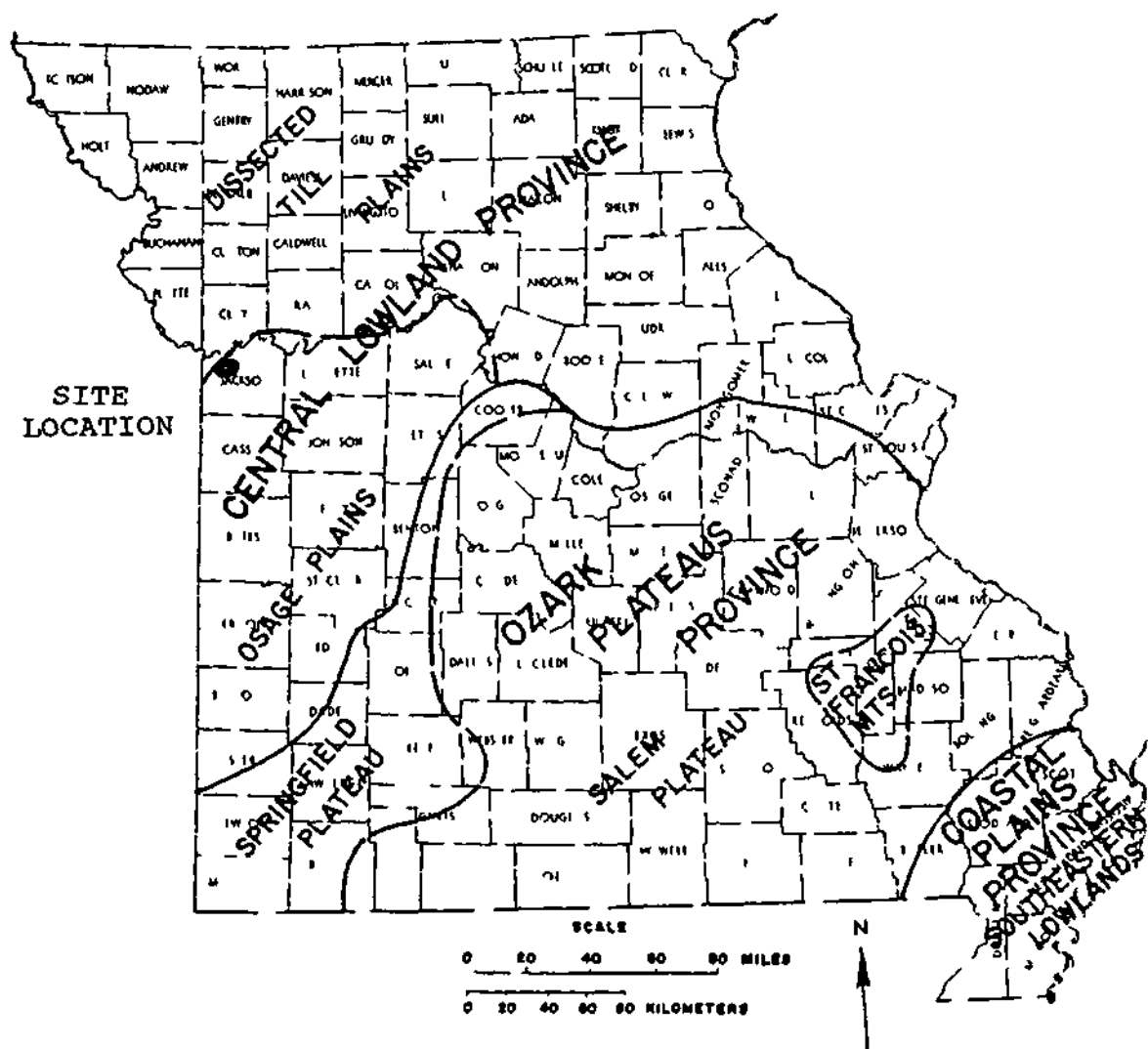
Missouri has varying geology ranging from Precambrian to Recent age deposits. Much of the landscape today is the result of three major geologic influences, (1) the uneven arching or uplifting of the bedrock (2) the erosion and weathering of various types of rocks and (3) the spreading of a thick mantle of clay, sand, and gravel over the bedrock by glaciers in the northern part of the state (3). As a result of this geologic activity, four North American physiographic provinces cross the State of Missouri, (1) the Central Lowland Province (2) the Ozark Plateau Province (3) the St. Francis Mountains, and (4) the Coastal Plains Province. These Provinces are shown on Figure 2.

The Central Lowland Province is divided into two subprovinces, the Dissected Till Plains and the Osage Plains. The Osage Plains are rolling plains of low relief founded on sedimentary rocks of the Pennsylvanian System. These plains encompass central western Missouri, including the area of the Elliott Shooting Park Site (4).

4 2 1 1 Bedrock Geology Rocks of the Pennsylvanian age, including the Pleasanton formation and Kansas City, Lansing, Marmaton, and Cherokee Groups, are present in the Osage Plains as shown on Figure 3. The development of escarpments (steep slopes and cliffs formed by erosion and faulting), plains, and other topographic features has been largely controlled by the rock types within these groups as shown on Figure 4.

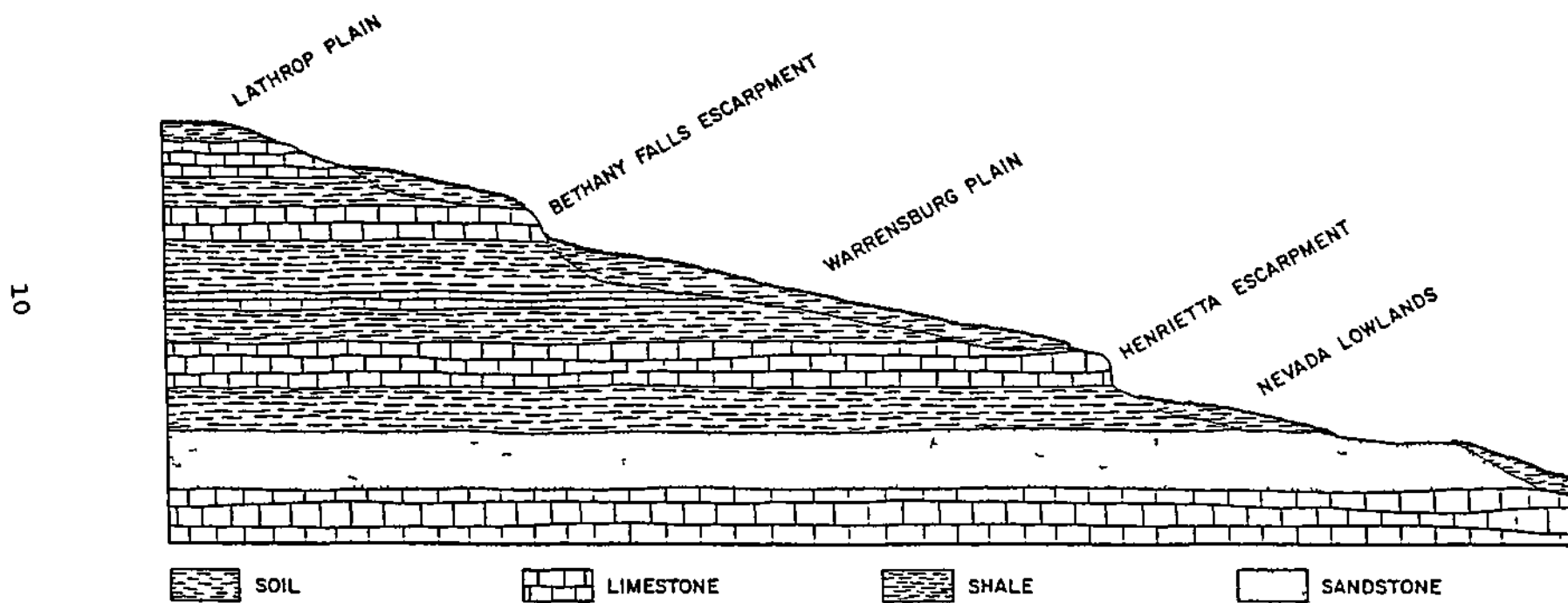
The Nevada Lowlands, the easternmost portion of the Osage Plains, is developed on less resistant shales and sandstones of the Cherokee Group. These deposits are cyclic sequences (cyclothems) of limestone, shale, sandstone, underclay, coal, and siltstone.

The Henrietta escarpment, formed by a relatively thick limestone (the Higginsville Formation), is the boundary between the Warrensburg Plain and the Nevada Lowlands to the south and east, respectively. The gently rolling Warrensburg Plain is developed on the soft shales and sandstones of the Marmaton and Pleasanton Groups. The discontinuous Warrensburg Sandstone Member of the Pleasanton group is a cross-bedded, channel-fill sandstone with an estimated maximum thickness of 150 feet.



Reference Geologic Aspects of Hazardous-Waste Isolation
in Missouri Missouri Department of Natural
Resources 1981

Figure 2 North American Physiographic Provinces Present in Missouri



Reference Geologic Aspects of Hazardous-Waste Isolation
in Missouri Missouri Department of Natural
Resources 1981

NOT TO SCALE

Figure 4 Cross Section, Northwest to Southeast, Across
the Osage Plains

The Lanthrop Plain which encompasses the Elliott Shooting Park Site is underlain by limestones and shales of the Kansas City Group. The topographic effects of resistant limestone are more noticeable on the Lanthrop Plain than on the Warrensburg Plain and the Nevada Lowlands. The escarpment of the Lanthrop Plain is formed by resistant limestones of the Swope Formation, particularly the Bethany Falls Limestone Member (5).

4 2 1 2 Structural Geology The geologic structure of the Osage Plains area includes folding and minor faulting. Individual structures, such as domes and folds, have produced gas, oil, or both in limited quantities.

Missouri is part of the stable Mid-continent, containing the deeply eroded Ozark uplift which has undergone repeated mild uplift since Precambrian time, exposing rocks ranging in age from Precambrian to late Paleozoic. To the northwest of the domal Ozark uplift lies the Forest City basin, containing late Paleozoic sedimentary rocks. The Elliott Shooting Park Site is located within this basin.

The fact that much of Missouri is a stable area, moving generally as a block, has kept folding to a minimum and no Alpine structures or tightly folded rocks occur. Most of the nearly 100 named anticlines in Missouri are in the western and northern parts of the state in basinal areas containing Pennsylvanian rocks. Folding, in many cases, may not be so much a result of lateral stress as it is a result of sedimentary rocks draping over a block-faulted Precambrian basement of competent crystalline rocks.

Steeply dipping beds are restricted to the immediate vicinity of faults, whereas, over most of the state, the regional dip is only a few degrees in magnitude. The dip of strata is generally quaquaversal (directed outward from a common center toward all points of the compass) with respect to the St. Francois Mountain area.

The more competent pre-Pennsylvanian rocks, especially the brittle carbonate and sandstone beds, tend to fail by fracturing and faulting rather than folding. About 200 named faults, many of which are accompanied by extensive brecciation, have displacement averaging about 100 feet. Faulting follows the Precambrian pattern of northwest-southeast trends with secondary northeast-southwest and east-west faulting. Many of these faults have had repeated movement.

Jointing is present in all rocks in the state, but is most pronounced in massively bedded Cambrian and Ordovician

dolomites, which also are the most cavernous rocks and contain most of the large springs of the state. Pseudo-structures formed by collapse of overlying beds into cavernous bedrock and other solution-caused structural features are common in central and southern parts of the state (6)

The Pennsylvanian aquifers of the Osage Plains are generally characterized by water table, or unconfined conditions. However, because of the geologic structure of this region, artesian, or confined, conditions may exist locally in shallow wells (5)

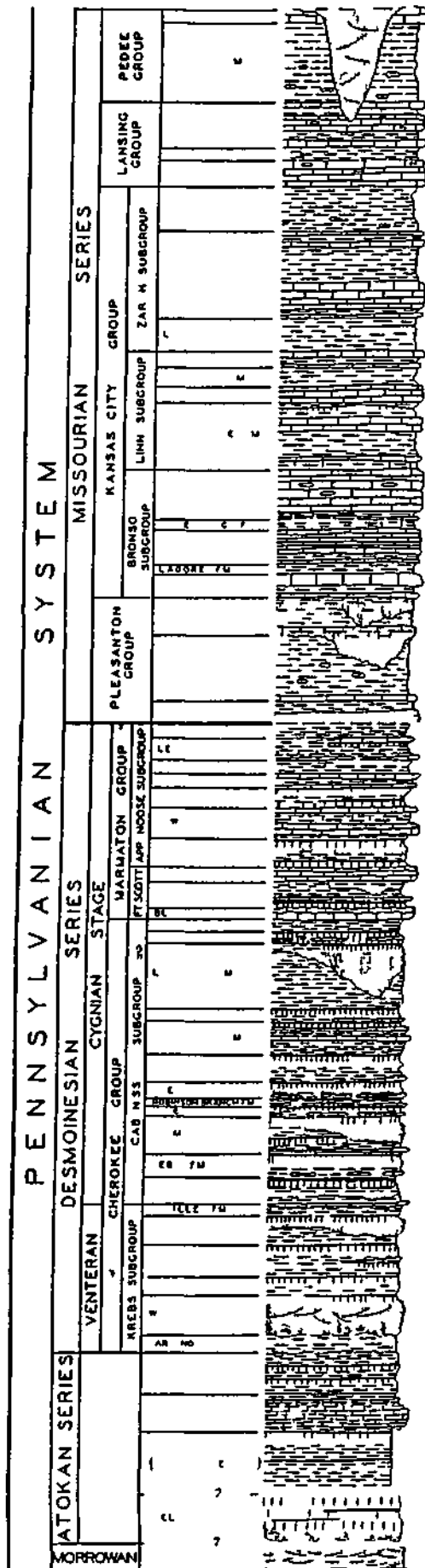
4 2 2 Local Geology

4 2 2 1 Bedrock Geology The Elliott Shooting Park site is located in the northwestern section of the Osage Plains. The geology of this region consists of bedrocks of the Missourian and Desmoinesian Series of the Pennsylvanian System.

The Missourian Series of bedrock totals approximately 570 feet in thickness and is divided into four groups, the Pleasanton, Kansas City, Lansing, and Pedee. The rocks forming these groups consist mainly of limestone, shale and sandstone-siltstone, and are present in a broad belt which underlies the entire Kansas City area. A stratigraphic column detailing the Pennsylvanian System for the Raytown area is shown on Figure 5.

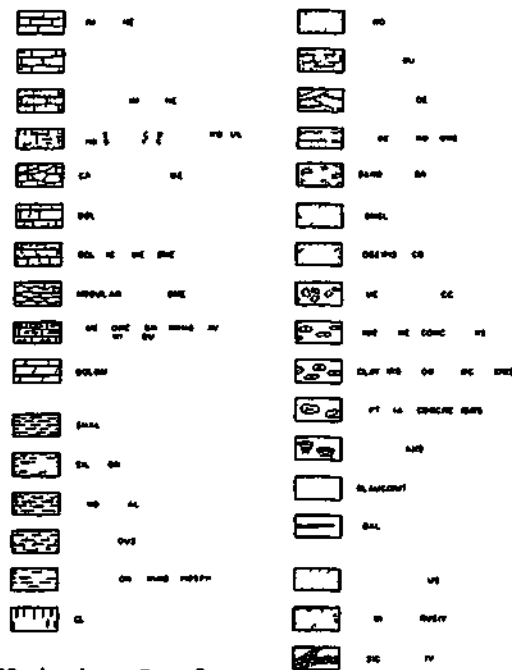
The Desmoinesian Series totals approximately 420 feet in thickness and is divided into two groups, the Cherokee and Marmaton. The major rock units which represent this time interval in Missouri are sandstone, siltstone, shale, clay, limestone and coal beds (7).

The locations of gas and oil wells of record near the Elliott Shooting Park Site are shown on Figure 6 (8,9). Geologic cross sections constructed North to South (A-A') and East to West (B-B') from the well log data of these wells are presented on Figures 7 and 8. As shown on these figures, the geology in the vicinity of the Elliott Shooting Park Site consists of the Pleasanton and Kansas City Groups of the Missourian Series and the Cherokee and Marmaton Group of the Desmoinesian Series.



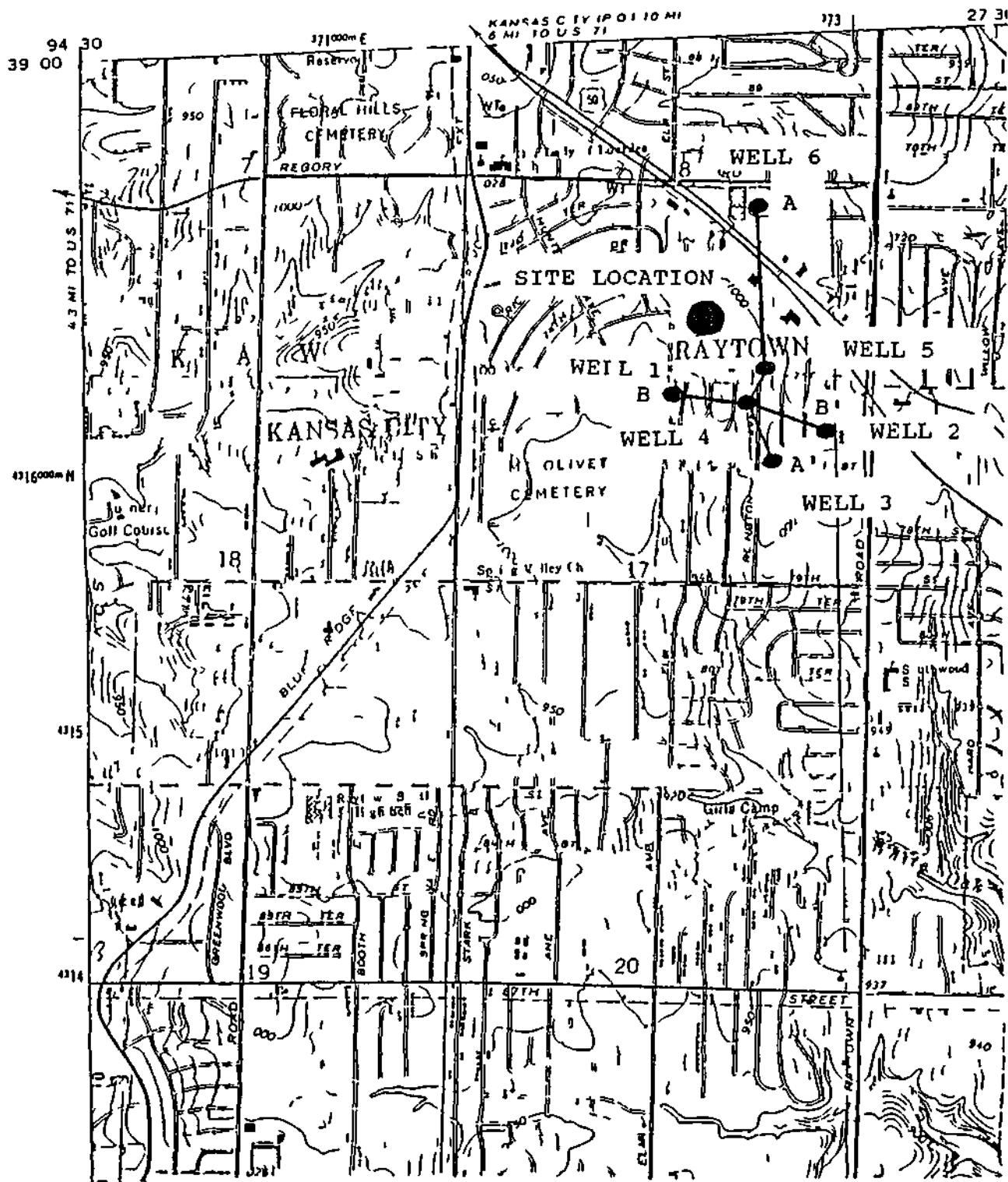
Reference Composite Stratigraphic Column for Missouri State of Missouri Department of Business and Administration Division of Geological Survey and Water Resources 1961

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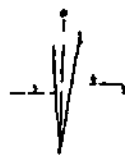
Not to Scale

Figure 5 Generalized Stratigraphic Column of Exposed Bedrock Near Raytown, Missouri



NOTES

- 1 Cross Section A-A is presented on Figure 7
- 2 Cross Section B-B is presented on Figure 8



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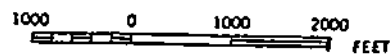


Figure 6 Gas and Oil Wells of Record Near the Elliott Shooting Park Site

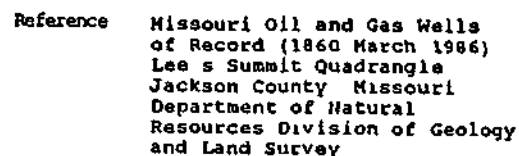


Figure 7 Geologic Cross Section A-A'

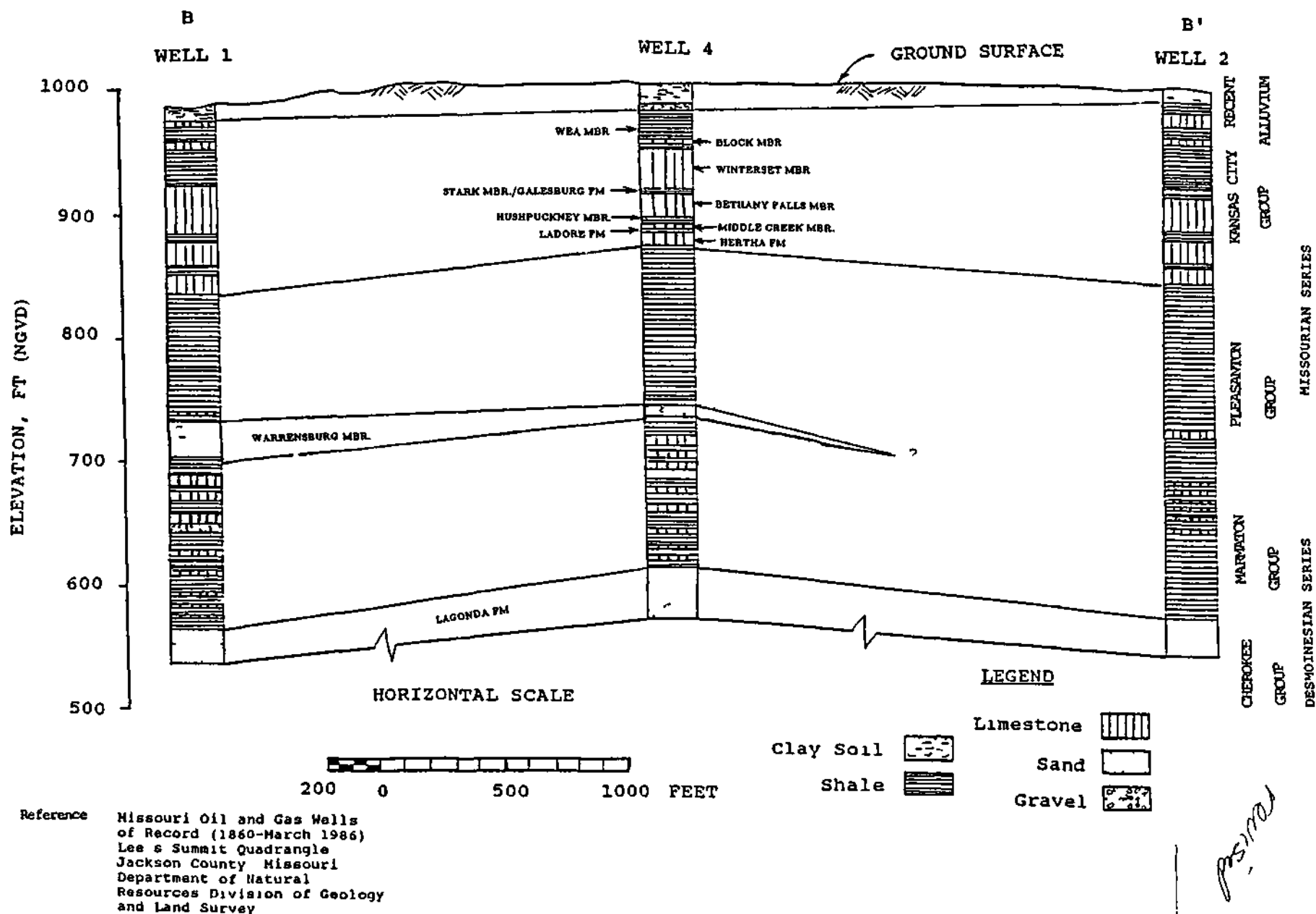


Figure 8 Geologic Cross Section B-B'

The Kansas City Group ranges from 120 to 135 feet in thickness and consists of ledge-forming limestones and intervening shale formations. None of these formations are considered potential aquifers in the vicinity of the site. The Hertha formation, approximately 10 feet in thickness, is one of five formations within the Kansas City Group and consists of limestone members separated by shale. The Swope formation within the Kansas City Group is subdivided into several members. The Bethany Falls Limestone member, noted in Figures 7 and 8, ranges from 20 to 25 feet in thickness. The upper Bethany Falls consists of many thin limestone beds expressed as a massive ledge and is characteristic of the local geology.

Below the Kansas City Group is the Pleasanton Group of the Missourian Series. The Pleasanton Group ranges from 20 to 150 feet in thickness and consists of firm and relatively watertight silty shale and sandstone. The sandstones generally have a high permeability and the silty shales have a low permeability. A channel-fill sandstone, referred to as the Warrensburg Sand, was located within the Warrensburg member during the drilling of wells 1, 4, and 6. This calcareous marine sandstone as well as the Warrensburg member is discontinuous throughout the Pleasanton Group. The Warrensburg member ranges in thickness from 5 to 150 feet. The channel-fill sandstone within the Warrensburg member ranges in thickness from 5 to 50 feet (10). Although the channel-fill sandstone is a laterally restricted sinuous deposit in the vicinity of the site, it is a potential aquifer. Groundwater within this deposit is anticipated to have a high mineral content and be of marginal quality.

The Pleasanton Group rests respectively on the Desmoinesian Series groups, the Marmaton and Cherokee. The Marmaton Group consists of a succession of shale, limestone, clay and coal beds. Compared with the Cherokee Group below, the Marmaton contains more limestone units which are also thicker and more persistent. Within the upper portion of the Cherokee Group is the Lagonda formation. This widespread formation is composed of shale, siltstone and sandstone and, locally, consists almost entirely of sandstone. The thickness of the Lagonda formation varies between 35 and 95 feet (7). The Lagonda Formation is a potential deep aquifer. Groundwater within the Lagonda Formation is expected to have an exceedingly high mineral content. It is anticipated that the quality of groundwater within this formation is below the chemical drinking water standards of the U. S. Public Health Service.

4 2 2 2 Structural Geology The Elliott Shooting Park Site is located in the Forest City Structural Basin. As shown on Figure 9, the Bannister Ridge Anticline crosses Jackson County in the vicinity of the site. The anticlinal area is made up of eight small closed domal structures clustered about a central depressed area. The structure is bounded on the west by the Penn Valley Syncline, on the south by the Ervine Syncline, on the north by the Jennings and Richards Field Depressions, and on the east by the Unity Syncline.

It appears that the Elliott Shooting Park Site may be located on the flank of the Richards Field Depression. This depression may influence the dip of the bedrock and, thus, the contaminant migration pattern in the vicinity of the site. It is possible that the depression may act as a catchment for contaminated leachate from the site for a limited time period. If sufficient leachate continues to collect in this depression, however, it could possibly act as a future contaminant spillway.

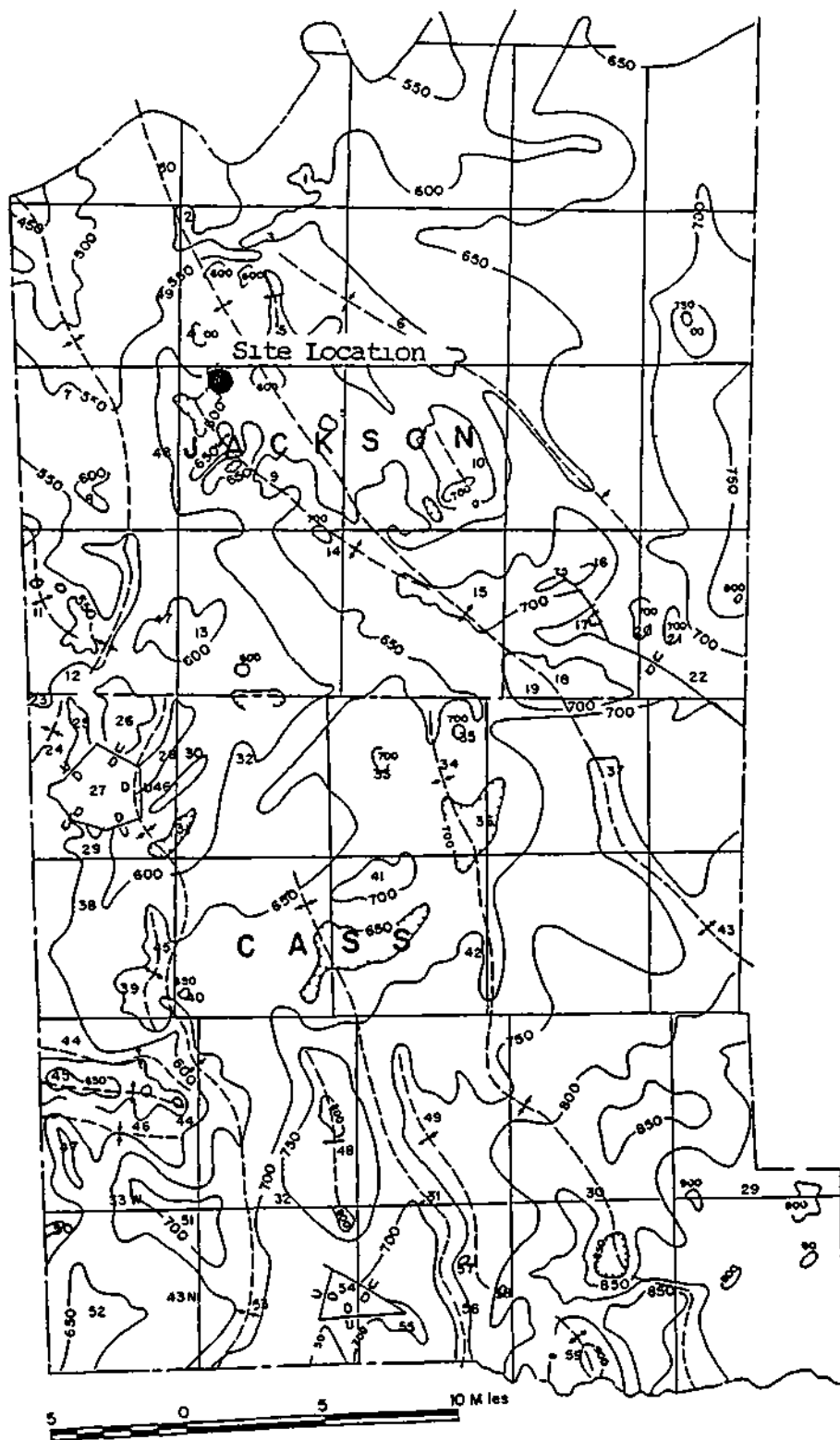
Fault zones, especially locally down-dropped block areas, are also possible within the Pennsylvanian rocks. In general, rocks near those structures dip steeply with the center containing beds younger than the periphery. They are not associated with regional structures, but are thought to be formed by the collapse of large pre-Pennsylvanian caverns developed in calcareous sediments beneath the Pennsylvanian rocks. Faults in the vicinity of the site are generally inactive (6).

The relatively consistent elevation differences of the geologic formations between well five and well four (shown on Figure 7) suggest that a fault system may be present between these two wells. This potential fault system, and other similar systems, may impact contaminant migration in the vicinity of the site by providing zones of high permeability along the displacements. In some locations, solution channels in limestone formations may also provide areas of greater permeability.

4 3 REGIONAL PHYSIOGRAPHY

The Osage Plains exhibit overall low relief, with prominent escarpments (steep slopes) caused by 10 to 30 feet of erosion-resistant limestone of Pennsylvanian age.

Upland surficial-material profiles have very thin loess over residuum on bedrock. The residuum (soil which is formed in



LEGEND

- 1 Independent nose
- 2 Central dome
- 3 Rock Creek nose
- 4 Rylwail
- 5 Bl Ridge
- 6 Kasa City Bl Spgs L e J k y d
- 7 South Kasa City dm
- 8 Id Creek dom
- 9 Ba ste Ridge tel e
- 10 Bl Spgs a l
- 11 M City tel
- 12 Pen Villy y cl
- 13 East G d w t l
- 14 Lees Summit
- 15 H t d m
- 16 Ad m Cm tery tel
- 17 Cock H t k
- 18 Ca terv ew Kasa City t l
- 19 Kopp dm
- 20 Sh wha dm
- 21 L Jack dom
- 22 Pow H Sch if lt
- 23 Joh t
- 24 H rry l
- 25 K och t l
- 26 K g dom (K g l l)
- 27 B it l t compl
- 28 Seba t l
- 29 Ja d t l e
- 30 M llen d oes
- 31 H r r lso s k
- 32 Playmor nose
- 33 North Coleman t l
- 34 D yto E st Ly ne Pleasa r H lly l
- 35 M h Q korest ant cl
- 36 Merv l depress
- 37 Str sb g ose
- 38 Wood t l
- 39 East Clav l d ant l
- 40 North Feema t l
- 41 Col m t cl
- 42 P rso mt l
- 43 Easter a t l
- 44 North West L y l
- 45 Feem West L t cl
- 46 West D la sy cl ne
- 47 L t a t l
- 48 Pr tyme t cl
- 49 H r rso ll t l
- 50 Kelly dm
- 51 H lss Creek So th Creek ant cl
- 52 D terrace
- 53 Bl Feema M Cr y syn line
(M Cr y B l t y t l)
- 54 E ert f k compl
- 55 Underbr k dom
- 56 Arch e-Lo e Tree-Peculiar syncline
- 57 N rth A t d m
- 58 A st dm
- 59 Ca tr l l

Contoured on the base of the Myrick Station Limestone Member
Contour Interval - 50 ft

Reference Structural Features of Missouri Missouri Geological Survey and Water Resources 1971

Figure 9 Geologic Structures of Cass and Jackson Counties

place) is derived from parent bedrock, including thick sandstones and limestones and thin cyclic deposits (cyclothems) of sandstone, shale, coal, limestone, siltstone, and clay

Loess, which constitutes the upper part of many soil profiles, increases in thickness northward. The soil developed on it has low to moderate plasticity, is moderately to highly erodible, and frequently develops a claypan subsoil of low permeability

Surficial materials average 20 feet thick and almost never exceed 40 feet, except for major valleys, in which alluvial thickness may reach 50 feet. Thickness of surficial materials varies considerably with the associated landforms. Limestone escarpments have thin cover, the low, broad, intervening landforms have thicknesses of 15 to 30 feet, and valleys generally have the thickest surficial materials (5)

4.4 REGIONAL SOILS

As shown on Figure 10, the soils in the vicinity of and underlying the site are loess deposits, which are nonstratified and unconsolidated sediments consisting mostly of silt-sized particles of quartz and feldspar. These particles were picked up by wind from glacial outwash plains and deposited downwind.

Soils of the Macksburg-Sharpsburg-Sampsel soil association are located directly below the Raytown area as shown on Figure 11. The soils of this association are poorly to moderately well drained and consist of silt loam and silty clay loam with varying amounts of clay and organic matter.

Urban development in the metropolitan Kansas City area has resulted in the reworking of the natural soil into urban soil complexes in the vicinity of the site. According to Figure 12, the Sibley-Urban land complex and the Higginsville-Urban complex are predominant near the Elliott Shooting Park site. The features of these soils are presented in Tables 1 and 2.

The Sibley-Urban land complex consists of deep, gently sloping, well drained Sibley soil and Urban land on moderately wide, convex ridges. Individual areas are irregular in shape and range from 40 to 700 acres. This

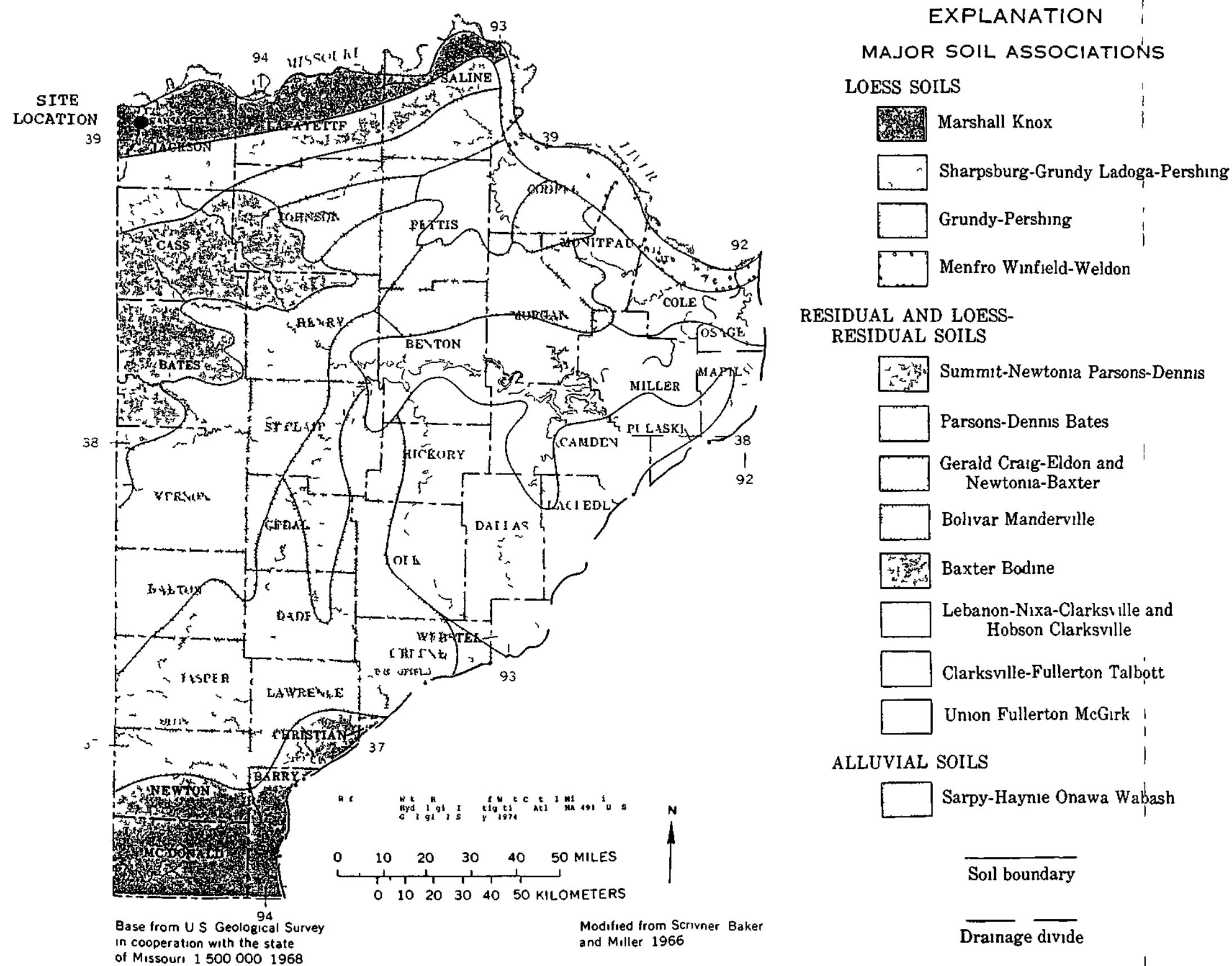
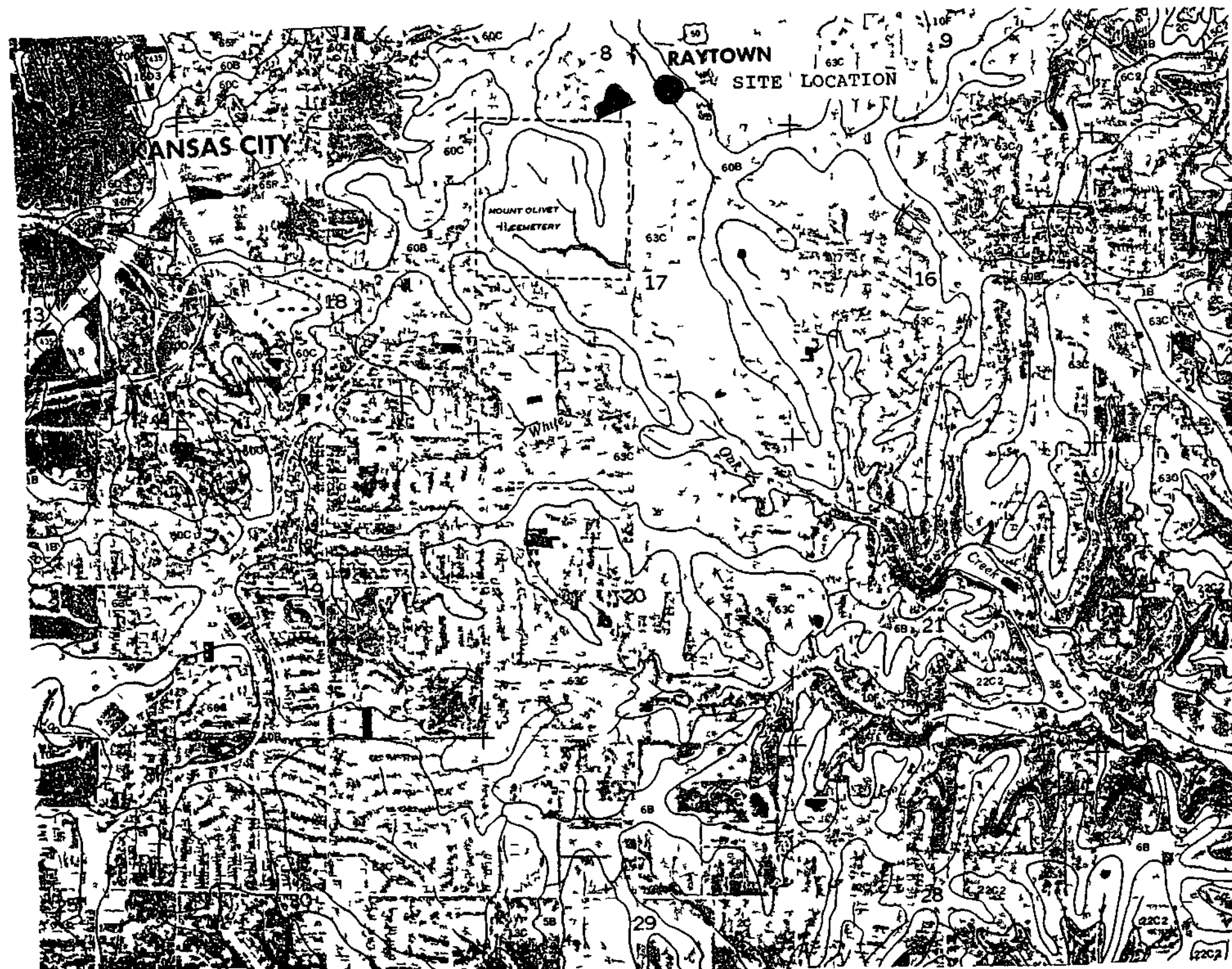


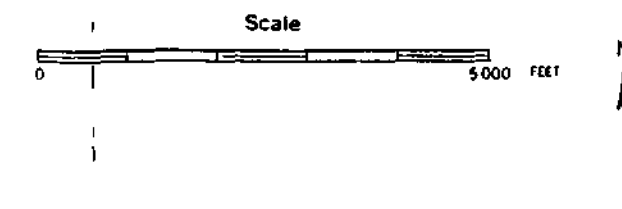
Figure 10 Major Soil Associations in Central Western Missouri

SOIL LEGEND

Map symbol codes are combinations of letters and numbers. The first letter indicates the soil type. Symbols with a letter following the number indicate the soil is a variant. Symbols with a letter following the number indicate the soil is a variant. A final number of 2 following the letter indicates the soil is a variant. A final number of 3 following the letter indicates the soil is a variant.

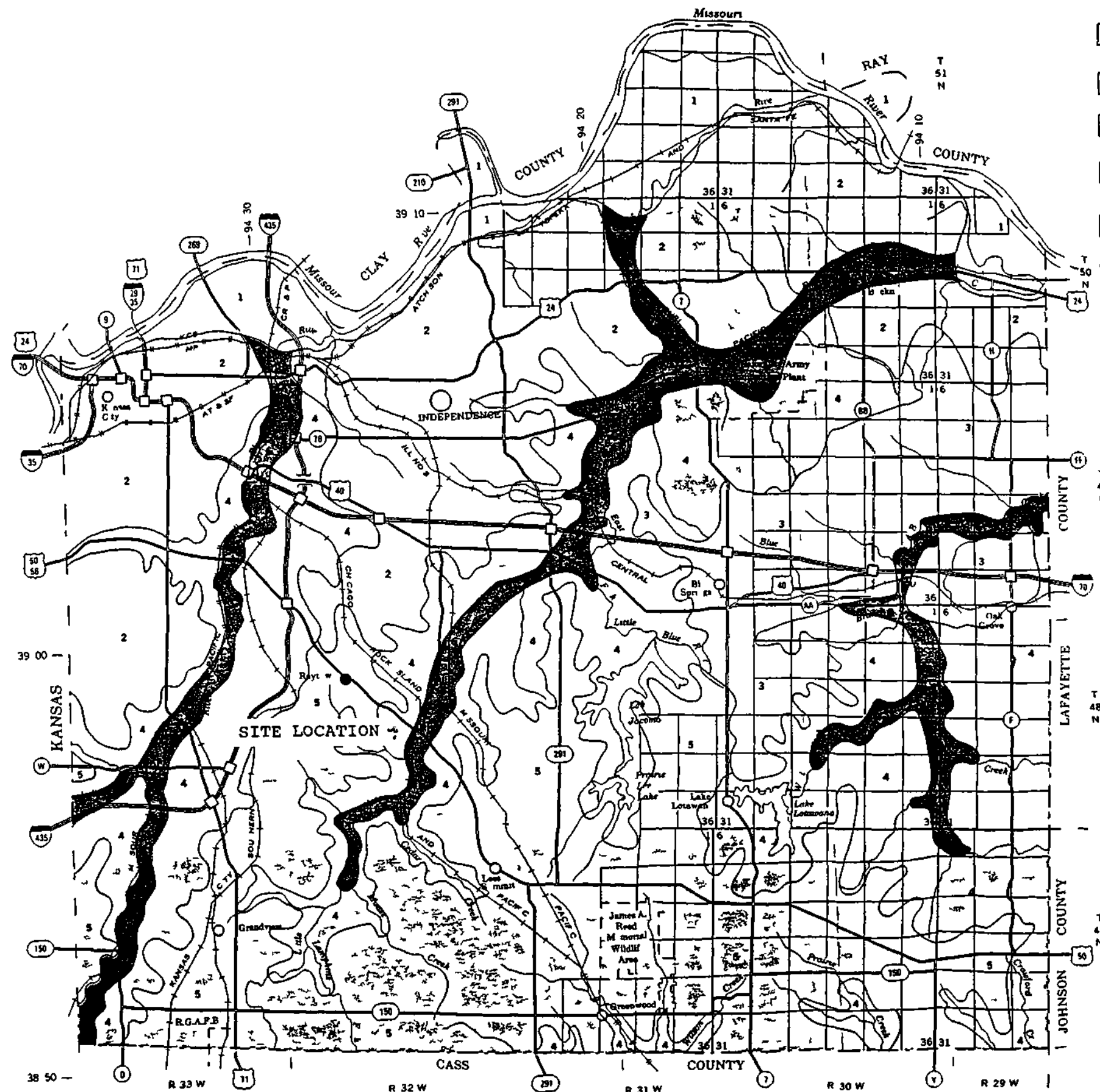


SYMBOL	NAME
1B	Sbley silt loam 2 to 5 percent slopes
1C	Sbley silt loam 5 to 9 percent slopes
2C	Higgins silt loam 5 to 9 percent slopes
5B	Macksb g silt loam 2 to 5 percent slopes
6B	Shapb g silt loam 2 to 5 percent slopes
6C2	Shapb g silt loam 5 to 9 percent slopes eroded
8	Pts q es
10D	Snead Rock outcrop complex 5 to 14 percent slopes
10F	Snead Rock outcrop complex 14 to 30 percent slopes
11C	Gentons silt clay loam 5 to 9 percent slopes
13B	Sampsel silt clay loam 2 to 5 percent slopes
13C	Sampsel silt clay loam 5 to 9 percent slopes
15B	Ment silt loam 2 to 5 percent slopes
15C2	Ment silt loam 5 to 9 percent slopes eroded
16D3	Ment silt clay loam 9 to 14 percent slopes severely eroded
17B	Polo silt loam 2 to 5 percent slopes
17C2	Polo silt loam 5 to 9 percent slopes eroded
19B	Wells silt loam 2 to 5 percent slopes
20C2	McG k silt loam 5 to 9 percent slopes eroded
22C2	Osk silt clay loam 5 to 9 percent slopes eroded
30	Ke ebec silt loam
31	Colo silt clay loam
33	Zook silt clay loam
36	Bemer silt loam
38	Wola silt loam
47D	Ma de lle silt loam 5 to 14 percent slopes
54C	K o silt loam 5 to 9 percent slopes
54E	K ox silt loam 14 to 20 percent slopes
54F	Kno silt loam 20 to 30 percent slopes
55D3	Kno silt clay loam 5 to 14 percent slopes severely eroded
60B	Sbley U ba land complex 2 to 5 percent slopes
60C	Sbley U ba land complex 5 to 9 percent slopes
61C	K o U ba land complex 5 to 9 percent slopes
61D	K o U ba land complex 9 to 14 percent slopes
62B	Macksb g U ba land complex 2 to 5 percent slopes
63C	Hgg s ile U ba land complex 5 to 9 percent slopes
64C	G ee ton U ba land complex 5 to 9 percent slopes
65F	S e d U b la d complex 9 to 30 percent slopes
68C	U ba la d pla d 5 to 9 percent slopes
68D	U b la d pla d 9 to 14 percent slopes
69A	U ba la d bottom la d 0 to 3 percent slopes
73	Leta silt clay
82	Pa k ile silt clay
83	Hay e silt loam
87	Modale silt loam
88	G il am silt clay loam
89	Sa py l e sa d
90	Wabash silt clay
91A	Nape silt loam 0 to 3 percent slopes
92	Cotter silt loam
100C	U ban land Harveste comple 2 to 9 percent slopes
102	Ud ilu e ts ea ly le el
103	Udo the ts ea ly le el



Reference Soil Survey of Jackson County Missouri U S Department of Agriculture Soil Conservation Service Missouri Agricultural Experimental Station 1984

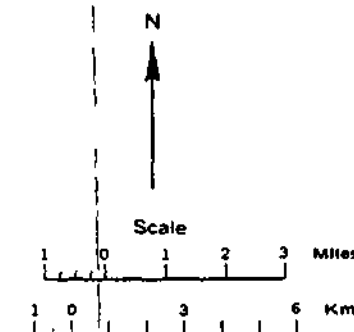
Figure 11 Classification of Soils Near the Elliott Shooting Park Site



SOIL ASSOCIATIONS

- 1 HAYNIE URBAN LAND-LETA association Urban land and deep nearly level moderately well drained and somewhat poorly drained soils that formed in alluvium on the Missouri River flood plain
- 2 KNOX-SIBLEY URBAN LAND association Urban land and deep gently sloping to steep well drained soils that formed in loess on uplands
- 3 HIGGINSVILLE SIBLEY SHARPSBURG association Deep gently sloping and moderately sloping somewhat poorly drained to well drained soils that formed in loess on uplands
- 4 SNEAD MENFRO OSKA association Moderately deep and deep gently sloping to steep well drained and moderately well drained soils that formed in loess or residuum from shale and limestone on uplands
- 5 MACKSBURG SHARPSBURG SAMPSEL association Deep gently sloping and moderately sloping moderately well drained to poorly drained soils that formed in loess or residuum from shale and limestone on uplands
- 6 KENNEBEC COLO BREMER association Deep nearly level moderately well drained and poorly drained soils that formed in alluvium on flood plains and terraces

Compiled 1983



Reference Soil Survey of Jackson County Missouri U S Department of Agriculture Soil Conservation Service Missouri Agricultural Experimental Station 1984

Figure 12 Relationship of Soils and Parent Material in the Macksburg-Sharpsburg-Sampsel Association

TABLE 1

Soil and Water Features Near the Elliott Shooting Park Site

Soil name and map symbol	Hydro- logic group	Flooding Frequency	High Water Table			Bedrock Depth	Depth	Clay	Moist bulk density g/cm ³	Permeability In/hr
			Depth	Kind	Months					
						In	In	Pct.		
60B 60C Sibley	B	None	>6 0	-	-	>60	0-15	20-30	1 20-1 50	0 6-2 0
							15-54	28-38	1 30-1 50	0 6-2 0
							54-76	20-30	1 20-1 50	0 6-2 0
63C Higginsville	C	None	1 5-3 0	Perched	Nov-Apr	>60	0-12	20-27	1 30-1 50	0 6-2 0
							12-18	27-35	1 30-1 40	0 6-2 0
							18-49	27-35	1 40-1 50	0 6-2 0
							49-60	25-30	1 50-1 60	0 6-2 0

TABLE 2

Engineering Index Properties
of Soil Near the Elliott Shooting Park Site

Soil name and map symbol	Depth (In)	USDA texture	Classification		Fragments >3 in (Pct)	Percentage passing sieve number				Liquid limit (Pct)	Plasticity index
			Unified	AASHTO		4	10	40	200		
630 Higginsville	0-12	Silt loam	CL	A-6	0	100	100	95-100	95-100	30-40	10-15
	12-18	Silty clay loam	CL	A-6 A-7	0	100	100	95-100	90-100	35-50	15-25
	18-49	Silty clay loam	CL	A-7	0	100	100	95-100	90-100	40-50	15-25
	49-60	Silty clay loam silt loam	CL ML	A-6 A-7	0	100	100	95-100	90-100	35-45	10-20
60B 60C Sibley	0-15	Silt loam	CL	A-6	0	100	100	95-100	90-100	30-40	10-20
	15-54	Silty clay loam	CL CH	A-7	0	100	100	95-100	90-100	40-55	20-35
	54-76	Silt loam silty clay loam	CL	A-6 A-7	0	100	100	95-100	90-100	35-45	15-25

Reference Soil Survey of Jackson County Missouri U S
Department of Agriculture Soil Conservation
Service Missouri Agricultural Experimental
Station 1984

complex is about 60 percent Sibley soil and 35 percent Urban land

Typically, the Sibley soil has a surface layer of very dark brown, friable silt loam about 6 inches thick. The subsurface layers are very dark brown, friable silt loam and very dark grayish brown friable silty clay loam about 17 inches thick. The subsoil is firm silty clay loam about 42 inches thick. The substratum to a depth of about 76 inches is mottled grayish brown and yellowish brown, friable silt loam.

Permeability is moderate in this Sibley soil, and surface runoff is medium. Natural fertility is high, and organic matter content is moderate. The pH of the upper three feet of Sibley soil is neutral to slightly acidic.

The Higginsville-Urban land complex consists of moderately sloping, somewhat poorly drained Higginsville soil and Urban land on side slopes. Individual areas are irregular in shape and range from 25 to 100 acres. This complex is about 60 percent Higginsville soil and 35 percent Urban land.

Typically, the Higginsville soil has a surface layer of very dark brown, friable silt loam about 7 inches thick. The subsurface layer is very dark brown, friable silt loam about 5 inches thick. The subsoil is about 37 inches thick. The upper part is very dark grayish brown, friable silty clay loam, the middle part is dark brown and brown mottled, firm silty clay loam, and the lower part is grayish brown, mottled, firm silty clay loam. The substratum to a depth of about 60 inches is grayish brown, mottled, friable silty clay loam.

Permeability is moderate in this Higginsville soil, and surface runoff is rapid. Natural fertility is high, and organic matter content is moderate. A seasonal high water table exists at a depth of 1.5 to 3 feet. Soils of the Higginsville Urban land complex are moderately acidic (11).

Urbanization of land may result in removal of the surface layer and exposure of subsurface layers that contain more clay. The removal of the surface layer results in the removal of organic matter and the compaction of clay layers near the surface.

The compaction of the surface clay layer reduces the ability of the water to percolate vertically downward towards the water table, thereby limiting the vertical migration of any contaminants. The urbanization of an area also results in

the construction of roads, parking lots and buildings, all of impermeable materials which inhibit the infiltration of surface water. This reduces the contaminant migration since there is less water available to carry contaminants to the groundwater table.

4 5 HYDROGEOLOGY

4 5 1 Regional Hydrogeology

The groundwater resources of Missouri, including major aquifer systems and their approximate yields are presented on Plate 1 located at the end of this report.

As shown on this plate, aquifers in central western Missouri may be classified in two groups, (1) unconsolidated aquifers (glacial drift and alluvium), and (2) bedrock aquifers of Pennsylvanian and Mississippian age. These aquifer systems are discussed in the following subsections.

4 5 1 1 Unconsolidated Aquifers With the exception of the Missouri River alluvium, unconsolidated aquifers are limited in extent in central western Missouri. These aquifers are present primarily in buried bedrock valleys and glacial drift deposits.

In northern Missouri, glacial deposits overlie the older consolidated rocks. The southern boundary of these deposits is 3 to 25 miles south of the Missouri River in the western part of the State and conforms approximately to the course of the river in the eastern part. Locally, the glacial drift contains sand deposits which, at present, are developed largely for domestic and small municipal supplies, but are capable of supplying larger quantities of water along the courses of buried glacial valleys (4).

The unconsolidated deposits (surficial materials) present within the area of the Lee's Summit Quadrangle (including the Elliott Shooting Park Site) are composed of alluvial and terrace deposits in and along the major stream valleys, plus upland soils and loessial deposits. No glacial till has been observed or reported for the area, and it is assumed not to have been glaciated (10).

Favorable areas for developing wells with yields of 10 to 1000 gallons per minute (gpm) in unconsolidated deposits in central western Missouri are shown on Figure 13.

The alluvial water resources in Jackson County are much better than those of the bedrock. The Missouri River alluvium in northern Jackson County is highly water-productive, capable of yielding more than 1,000 gallons per minute to properly located and constructed gravel-pack wells. The Little Blue River alluvium is also water productive, though its yield is considerably less than that of the Missouri River alluvium (12)

The principal source of present and future groundwater supplies for Jackson County is the Missouri River alluvium. This source is widely used in Independence and other cities in Jackson county. Water for Kansas City comes directly from the Missouri River. The source of water for rural water districts is the Missouri River alluvium.

The water table in the Missouri River alluvium generally is between 5 and 25 feet below the surface of the flood plain. The alluvium reaches a maximum of 100 feet in thickness and averages between 80 and 90 feet (11)

Groundwater in the alluvium tends to be high in iron, bicarbonates, and other dissolved solids. Because of subdued relief and shallow stream gradients, groundwater movement is generally slow (5)

4 5 1 2 Bedrock Aquifers Shallow bedrock aquifers in central western Missouri are very limited because the upper 600 feet of strata consist of Pennsylvanian cyclothemic deposits of limestone, sandstone, and shale. Permeabilities are generally low in unfractured material.

Water from the Pennsylvanian age bedrock is of marginal quality because of its high mineral content. This water usually does not meet minimum public drinking water standards, but was used as a farm and household water supply before public water was available. Years ago, hand-dug wells 10 to 30 feet in depth were often used. These were recharged by water in surficial materials. Though the very shallow water is generally less mineralized, this type of well is highly prone to bacterial contamination. Wells completely penetrating the Pennsylvanian bedrock may contain water with total dissolved solids of 10,000 to 20,000 milligrams per liter (mg/l) (12)

SITE LOCATION

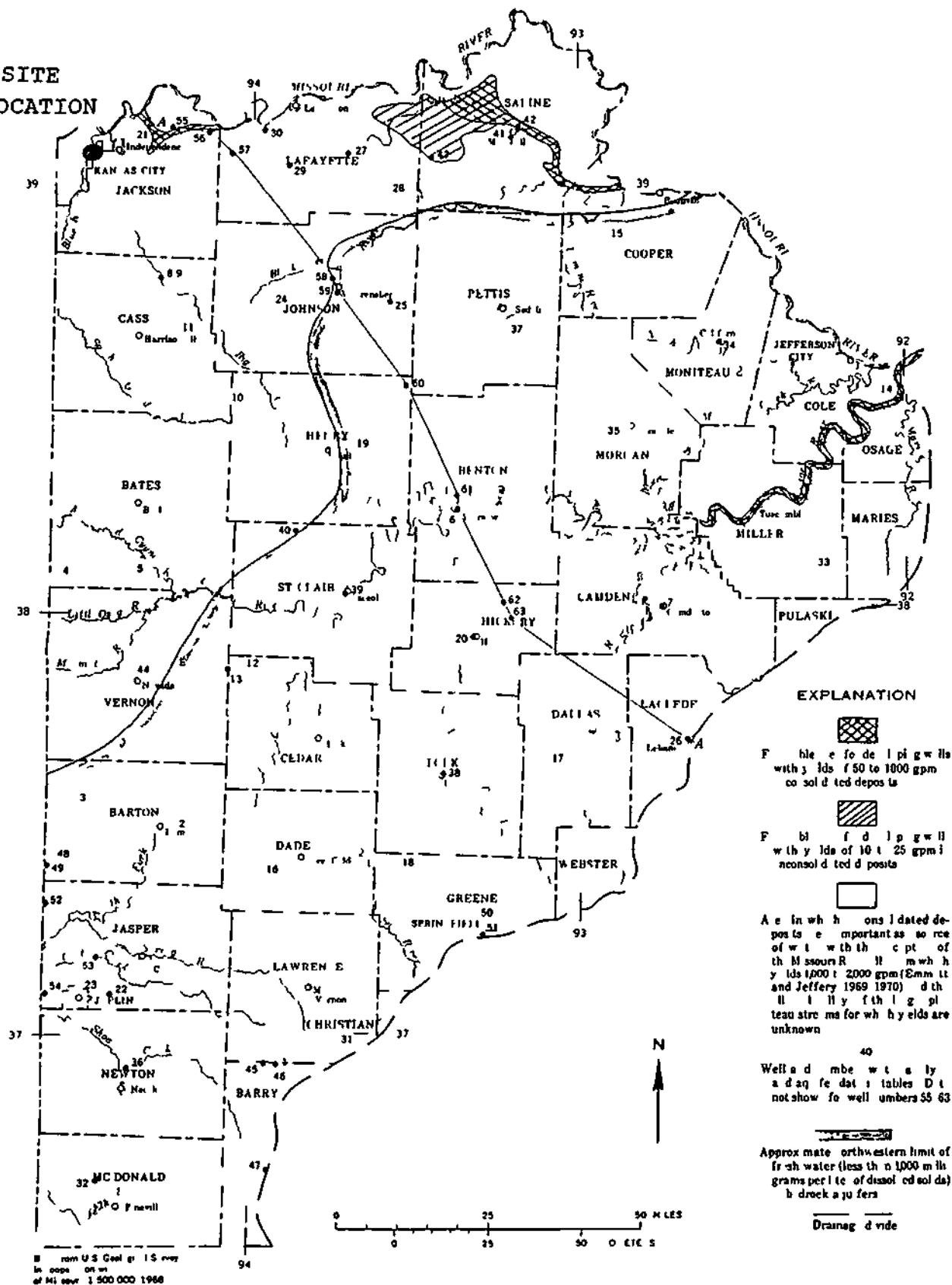


Figure 13 Favorable Areas for Developing Wells in Central Western Missouri and Southwest Missouri

Deeper aquifers in the Mississippian and Ordovician strata in central western Missouri are also known to contain highly mineralized water as shown on Figures 14 and 15. Circulation in these deep aquifers is quite poor, allowing large amounts of material to be dissolved. Bedrock formations in central western Missouri dip gently toward the northwest with near-surface rocks becoming progressively younger in age in that direction. The dissolved solids content and chloride content increases towards the northwest along the dip of the bedrock formations. Concentrations of total dissolved solids and chlorides in groundwater samples from deep wells in Missouri are presented on Plate 2 at the end of this report. The areas in which the quality of groundwater is below the chemical drinking water standards of the U. S. Public Health Service are also shown on this plate. The U. S. Public Health Service (1962) drinking water standard for maximum chloride content is 250 milligrams per liter (13).

Chemical analyses results of groundwater from four deep wells in the Kansas City area are presented in Table 3. These results are typical of the quality of groundwater from deep aquifers in central western Missouri.

All groundwater in the Cambrian and Ordovician aquifers in Jackson County is considered saline because this area is northwest of the approximate fresh water limit of 1,000 milligrams per liter of dissolved solids.

4 5 1 3 Springs The most favorable environment for the development of large spring systems in Missouri is the thick sequence of Cambrian and Ordovician dolomites of the Ozarks. The major cavernous carbonate rock formations in the Ozarks are the Gasconade, Eminence, and Potosi Dolomites. Because groundwater moves freely through the solution channels, these formations provide large quantities of water of fair quality at depth.

Springs in the Pennsylvanian rocks of western and northern Missouri are small and many are highly mineralized. Sedimentation in the Pennsylvanian Period was cyclic and produced thin rock units of contrasting lithology. In this area there are no thick sections of carbonate rocks, only thin limestone beds with intervening layers of shale, sandstone, siltstone, clay, or coal. There is no opportunity for the development of large integrated solution channels characteristic of large spring supply systems. The dissimilar rock layers impede the movement of groundwater and produce only small springs (4).

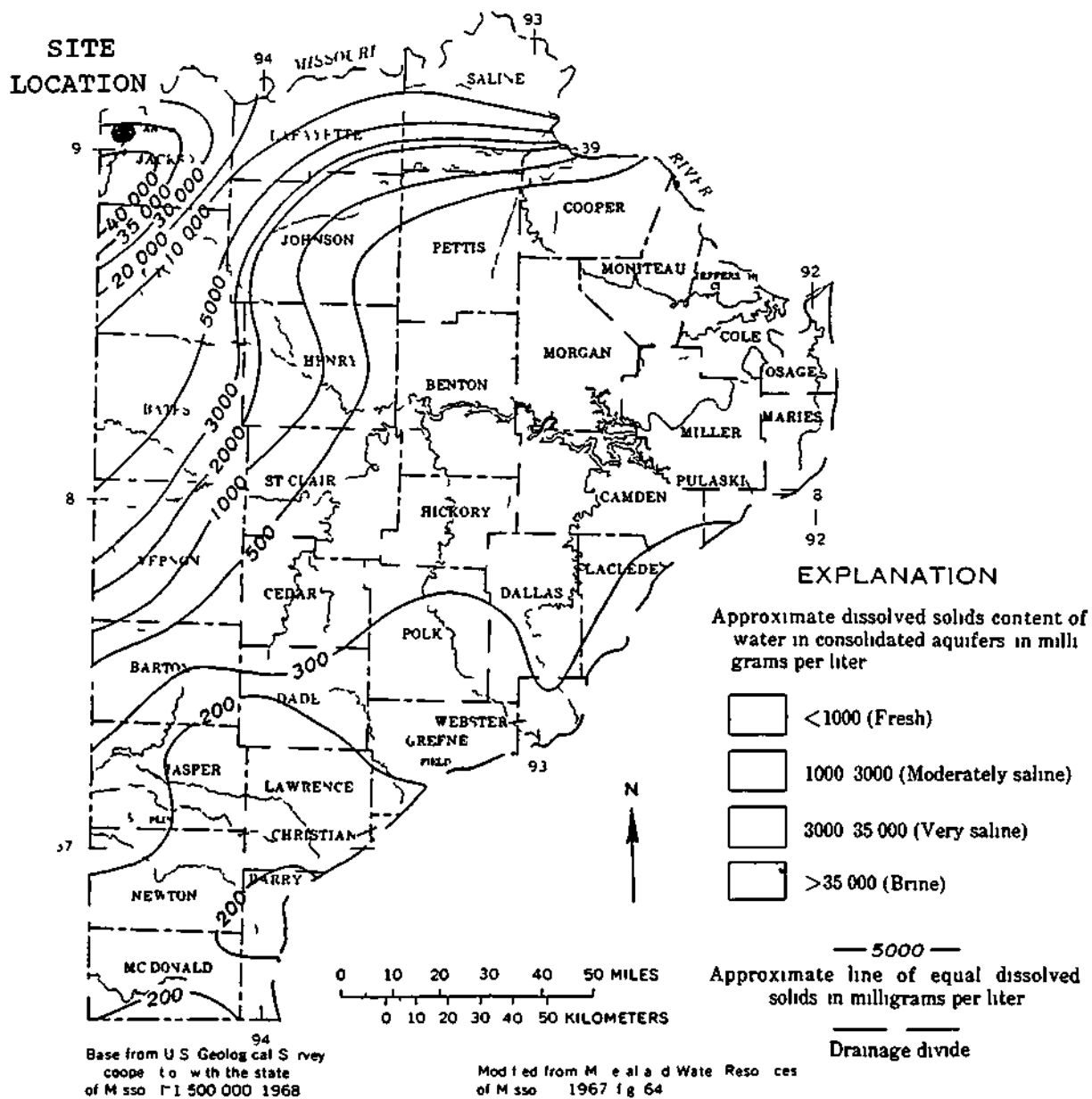
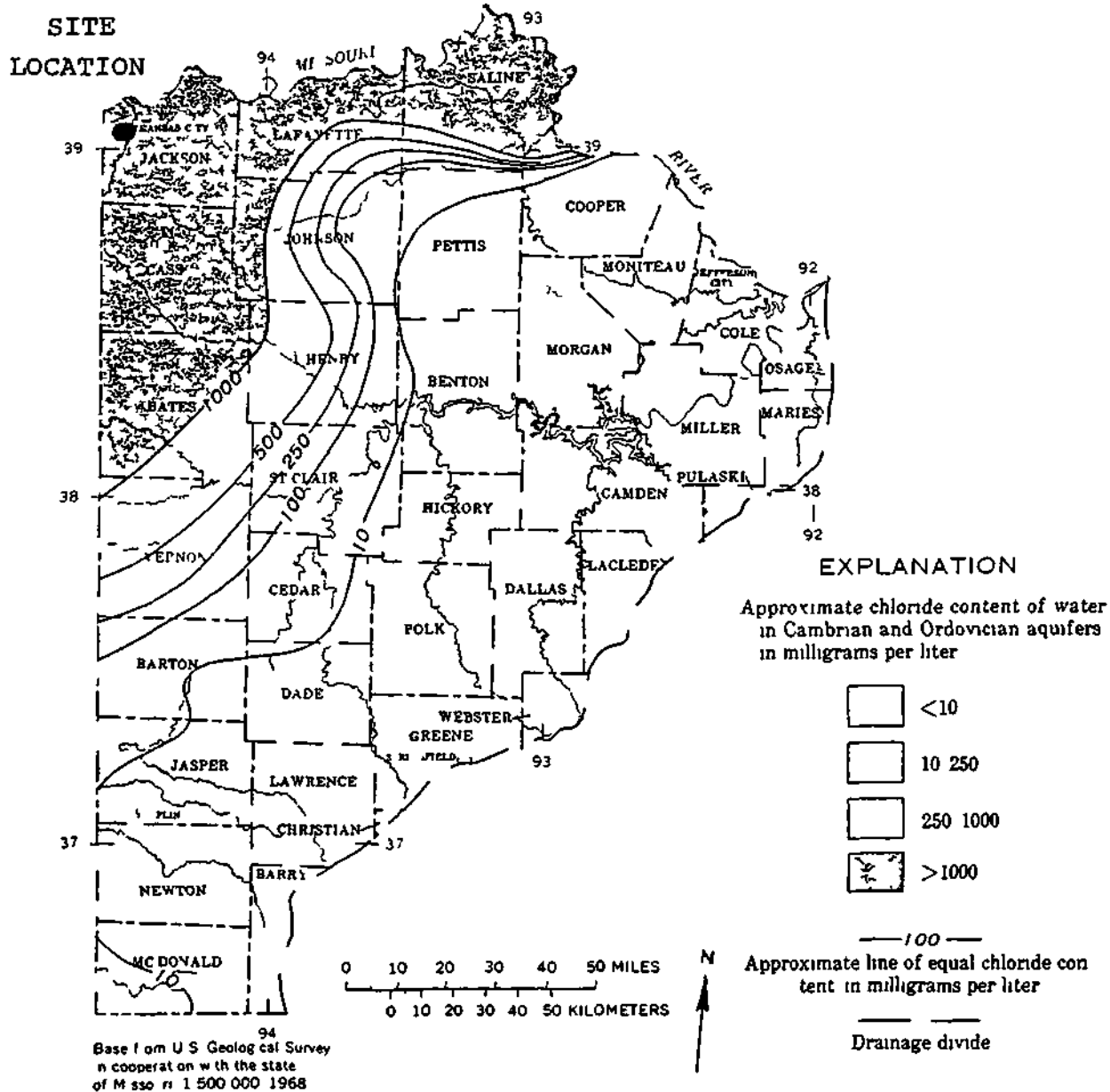


Figure 14 Approximate Dissolved Solids Content of Water in Consolidated Aquifers in Central Western Missouri and Southwest Missouri



Reference Water Resources of West-Central Missouri
Hydrologic Investigations Atlas HA-491 U.S.
Geological Survey 1974

Figure 15 Approximate Chloride Content of Water in Cambrian and Ordovician Aquifers in Central Western Missouri and Southwest Missouri

TABLE 3
ANALYSES OF DEEP WELL WATERS OF KANSAS CITY
(Parts per million)

Constituent	1	2	3	4
Silica (SiO ₂)	2	4	69 8	20 5
Alumina (Al ₂ O ₃)				11 1
Ferric oxide (Fe ₂ O ₃)				47 1
Ferrous carbonate (FeCO ₃)			100 5	
Calcium carbonate (CaCO ₃)	67	109	899 1	444 2
Magnesium carbonate (MgCO ₃)			268 4	157 9
Sodium carbonate (Na ₂ CO ₃)			144 1	261 4
Calcium sulphate (CaSO ₄)	24	11	77 5	
Magnesium sulphate (MgSO ₄)				12 8
Calcium chloride (CaCl ₂)	1,166	1,196		246 2
Magnesium chloride (MgCl ₂)	785	871		
Sodium chloride (NaCl)	24,420	25,090	25,150 8	21,056 2
Potassium chloride (KCl)	370	380		608 1
Carbon dioxide (CO ₂) (free)			376 2	293 4
Mineral matter	26,834	27,661	27,086 4	23,158 9

- 1 W S Dickey well, Fifty-first and Holmes Water from 250-foot level partial analysis made at laboratory of the Bureau of Geology and Mines
- 2 W S Dickey well, Fifty-first and Holmes, from 450-foot level, partial analysis made at the laboratory of the Bureau of Geology and Mines
- 3 Young's medicinal well, Twenty-fifth and vine, analysis by C C Hamilton, about 1890
- 4 Magnesio-Saline Mineral Springs (well), Kensington and Cincinnati, analyses by C C Hamilton and R R Hunter, August, 1891

Reference Geology of Jackson County, by W E McCourt, 1917

4 5 2 Local Hydrogeology

As shown previously on Figure 13, unconsolidated materials in the Raytown area are not considered feasible for development of wells with yields of 10 gpm or greater. Recent alluvium in the vicinity of the site is present at the surface. However, according to the geologic cross-sections developed from local well logs, the alluvium is limited to an approximate thickness of 20 feet. No other continuous permeable strata of considerable thickness is present within 175 feet of the ground surface.

The depth to groundwater in the vicinity of the site is approximately 50 feet (8). Groundwater flow in shallow unconsolidated materials is anticipated to follow surface drainage patterns. The direction of groundwater flow in deeper consolidated deposits is unknown. Water table or confined conditions may exist at depth, depending on local geologic folding and minor faulting.

Based on the lithological descriptions and the well log data presented in the local geology section, the shallowest aquifer of widespread significance in the vicinity of the Elliott Shooting Park is most likely the Lagonda formation of the Cherokee Group. The average depth of this formation is 425 feet below the ground surface. The regional thickness of this formation varies from 35 to 95 feet. Because local well logs were discontinued in this formation, its local thickness is not known. According to Plate 1 at the end of this report, well yields from this formation are anticipated to range from 1 to 15 gallons per minute.

The groundwater contained within the Lagonda formation is expected to be below the chemical drinking water standards of the U. S. Public Health Service due to exceedingly high concentrations of total dissolved solids and chlorides. Based on Plate 2 at the end of this report, the total dissolved solids and chloride concentrations for this formation are anticipated to be approximately 20,000 milligrams per liter and 11,000 milligrams per liter, respectively.

The local geology above the Lagonda formation, except for isolated branches of the Warrensburg channel-fill sandstone, consists mainly of impervious material. The channel-fill sandstone within the Warrensburg member appears to cross a portion of the site at an approximate depth of 200 feet below the ground surface. However, since this formation is a laterally restricted sinuous deposit, it is unlikely that this deposit is a significant aquifer in the vicinity of the site. According to Plate 1, well yields from the

Warrensburg channel sandstones are estimated to be zero to 25 gallons per minute. The quality of groundwater from this formation is anticipated to be poor, but lower in total dissolved solids and chlorides compared to groundwater in the Lagonda formation.

Isolated perched systems (saturated pockets of sand and gravel above the normal water table) may be present in the vicinity of the site during periods of high precipitation because of the numerous relatively impermeable strata within the region. Yields of shallow wells in the perched systems are generally low (0 to 5 gpm) and many of these wells go dry during periods of low rainfall (11). Thus, these systems are not anticipated to be of widespread significance because they are laterally restricted and undependable.

5 0 GROUNDWATER USE INVESTIGATION

A Groundwater use investigation was conducted to identify potential receptors of lead-contaminated groundwater in the vicinity of the site. This investigation consisted of examining records of water samples submitted by local residents to the State Health Department for bacterial testing, contacting the local water districts serving the Raytown Area, conducting a survey of potential residential wells near the site, and contacting a local geotechnical company concerning installation and maintenance of private wells in the Raytown area.

5 1 JACKSON COUNTY AND STATE OF MISSOURI HEALTH DEPARTMENTS

The Jackson County Health Department and the State Health Department were contacted in an attempt to identify private wells in the vicinity of the site. Both agencies reported that they were not aware of any private wells within the city limits of Raytown (14, 15).

The records of water samples submitted by local residents to the State Health Department for bacterial testing for the period of 1980 to 1987 were also reviewed. From these records, a few residents were identified as potential users of a private water supply.

These potential receptors were contacted to determine if they obtained their domestic water from a private well. All residents reported that their domestic water supply was city water.

5 2 MUNICIPAL WATER DISTRICTS SERVING RAYTOWN, MISSOURI

Several municipal water districts were contacted during this investigation to determine the sources of domestic water for the Raytown area.

According to the Raytown Public Works Department, the public water supply for Raytown is purchased from the water departments of Kansas City, Missouri and Independence, Missouri. The City Engineer, Mr. Gene Yeokum, was not aware of any private wells in the Raytown area (16).

The water departments of Kansas City, Missouri and Independence, Missouri reported that they obtain water from wells located in the Missouri River alluvium, approximately nine miles north of the site.

5 3 PRIVATE DRILLING CONTRACTOR

In an attempt to locate private water wells in the vicinity of the site, the Layne Western Company of Kansas City was contacted. Layne Western is a large geotechnical firm specializing in water well installation and maintenance. The company representative, Mr. Jeff Hall, reported that Layne Western did not have any records of wells installed or serviced in the Raytown area. Mr. Hall also stated that yields from surficial aquifers near Raytown were generally very low, except along the Blue River (17)

5 4 PRIVATE/RESIDENTIAL WELLS

Oil and gas wells of record were investigated in this study as potential private water supplies. According to Dr. Paul L. Hilpman, Professor of Geology at the University of Missouri at Kansas City, wells drilled in the Raytown area for collection of oil or gas may potentially have been converted to private water supply wells, depending on the subsurface conditions encountered during drilling (18)

Residents near the site where oil and gas wells were reported to have been installed were contacted to determine if any local water supply wells exist. Residents along Elm Avenue, Arlington Avenue, and 75th Street near the well locations shown on the Map of Oil and Gas Wells of Record were contacted in this investigation (9). The names and telephone numbers of these residents are provided in Appendix B. None of the residents contacted were aware of any oil, gas, or water wells in the local area.

6 0 ASSESSMENT OF POTENTIAL CONTAMINANT MIGRATION AND
HUMAN CONSUMPTION OF CONTAMINATED GROUNDWATER IN
THE VICINITY OF THE ELLIOTT SHOOTING PARK SITE

6 1 INTERPRETATIONS OF HYDROGEOLOGICAL AND GROUNDWATER
USAGE DATA

The potential of lead contamination of local aquifers in the vicinity of the Elliott Shooting Park Site and human consumption of groundwater from these aquifers is very low. The high concentrations of lead in the site surface soils provide a source of potential groundwater contamination. However, the lead from the lead shot would be released slowly to the environment over extended periods of exposure because of its low solubility in water. In addition, the local soils and subsurface geology generally restrict contaminant migration because of the high content of clay in the surface soils and the presence of numerous relatively impermeable shale layers at depth. The threat of human consumption of groundwater from local aquifers is low because the area surrounding the site is served by a municipal water district, no private wells are known to exist in the vicinity of the site, and it is presumed that groundwater in the immediate area is not potable.

The permeabilities of surface soils in the vicinity of the site are moderate (0.6 to 2.0 inches/hour) due to the fine texture of the soils. These soils restrict infiltration of precipitation and the leaching of contaminants from the soil. In addition, paved and concrete areas near the site reduce infiltration and therefore inhibit contaminant migration. Surface soils, which are composed of approximately 30 percent clay and have a moderate organic content, also reduce contaminant migration by adsorption of contaminants by the soil particles. Leaching of lead is not expected to be great because the surface soils are neutral to moderately acidic.

The low permeability of the Pennsylvanian strata underlying the site also impedes groundwater movement both laterally and vertically. Contaminants which slowly migrate vertically through the Pennsylvanian strata are likely to be absorbed by the organic matter in the shale formations.

Contaminant migration may be possible in areas where casings of old oil and gas wells have deteriorated. In these areas, the potential exists for contaminants to migrate vertically within the casings and then horizontally through the voids along the top of relatively impermeable layers, ultimately

discharging at outcrops to surface valleys (18) The threat of surface water contamination by local runoff and ground-water flow, however, is judged to be low because surface water bodies in this region are a considerable distance from the site

It appears that the Elliott Shooting Park Site may be located on the flank of the Richards Field Depression This depression may influence the dip of the bedrock and, thus, the contaminant migration pattern in the vicinity of the site It is possible that the depression may act as a catchment for contaminated leachate from the site for a limited time period If sufficient leachate continues to collect in this depression, however, it could possibly act as a future contaminant spillway

Fault zones, especially locally down dropped block areas, are possible within the Pennsylvanian rocks Potential fault systems (such as the system suspected between well five and well four shown on Figure 7) may impact contaminant migration in the vicinity of the site by providing zones of high permeability along the displacements In some locations, solution channels in limestone formations may also provide areas of greater permeability

CONEL { In the event that groundwater does become contaminated by lead from the site, the likelihood of human consumption of the contaminated groundwater is very remote

The shallowest aquifer of widespread significance in the local area is the Lagonda formation at a depth of 425 feet below the ground surface Installation of a well in the Lagonda formation is not considered feasible for development of a private water supply because of the formation's depth and exceedingly high mineral content of groundwater The quality of groundwater within the Lagonda formation is expected to be below the chemical drinking water standards of the U S Public Health Service

The channel-fill sandstone of the Warrensburg member appears to cross the site at an approximate depth of 200 feet below the ground surface However, the probability of this deposit being of widespread significance is very low The number of potential future users of groundwater from this formation is limited because it is a laterally restricted sinuous deposit The groundwater from this formation is anticipated to be of poor quality, but lower in total dissolved solids and chlorides compared to groundwater in the Lagonda formation Thus, future installation of a private well into the channel-fill sandstone of the Warrensburg member is also considered unlikely

Isolated perched aquifer systems may also be present within the study area during periods of high precipitation because of the numerous shallow relatively impermeable horizontal strata within the region. Yields of shallow wells in the perched systems are generally low (zero to five gallons per minute) and many of these wells go dry during periods of low rainfall. Thus, these systems are not anticipated to be of widespread significance because they are laterally restricted and undependable water supplies.

In summary, the potential of contaminant migration and human consumption of contaminated groundwater in the vicinity of the site is very low. The low permeability and moderate organic content of local soils and the general geologic stratigraphy are anticipated to inhibit the migration of lead from the soil to the local aquifer systems. Potential receptors of contaminated groundwater are also unlikely. Currently, no private or public wells are known to exist in the vicinity of the site. The probability of future installations of private wells in this area is also low because the entire area surrounding the site is served by a municipal water district. Installation of future wells for private water supplies is not considered feasible because the depth of local aquifers are anticipated to be 200 feet or greater and the quality of water at this depth is expected to be poor.

6.2 LIMITATIONS OF THIS STUDY

This report has been prepared using existing data in the vicinity of the Elliott Shooting Park Site. The analyses presented in this report are based upon data obtained from historical topographic maps and soil boring logs for wells located approximately 0.2 to 0.5 miles from the site and regional hydrogeological information provided by the references listed in Section 7.0. The report does not reflect any variations which may occur between borings or across the site. The nature and extent of such variations, if present, may not become evident unless site-specific investigations are conducted.

Should additional data on the site hydrogeology become available, Jacobs Engineering Group requests the opportunity to reevaluate any conclusions which may be impacted by the data. It is also recommended that a geotechnical engineer from Jacobs Engineering Group or their subcontractors be present at the site during any future well installations at the site to assist in logging of the geologic strata. Because specific geologic structures in the vicinity of the site were not assessed in detail in this report, additional research concerning structural geology in the vicinity of

the site is necessary before future investigations are conducted

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- 15 Personal Communication, Mr Bob Fields, Missouri
State Health Department, Raytown, Missouri (816-
353-9902)
- 16 Personal Communication, Mr Gene Yeokum, Public
Works Department, Raytown, Missouri (816-737-
0550)
- 17 Personal Communication, Mr Jeff Hall, Layne
Western Company, Inc , Kansas City, Missouri (816-
321-5000)
- 18 Personal Communication, Dr Paul L Hilpman,
Professor of Geology, Department of Geosciences,
University of Missouri at Kansas City (816-276-
1334)

APPENDIX A

LETTER FROM JAMES E VANDIKE, GEOLOGIST,
MISSOURI DEPARTMENT OF NATURAL RESOURCES,

TO J BIESMA,
JACOBS ENGINEERING GROUP,

AUGUST 10, 1987



JOHN ASHCROFT
Governor

FREDERICK A. BRUNNER
Director

Division of Energy
Division of Environmental Quality
Division of Geology and Land Survey
Division of Management Services
Division of Parks, Recreation
and Historic Preservation

STATE OF MISSOURI
DEPARTMENT OF NATURAL RESOURCES

DIVISION OF GEOLOGY & LAND SURVEY
P O Box 250 111 Fairgrounds Road
Rolla MO 65401
314 364 1752

August 10, 1987

Ms Jill Biesma
Jacobs Engineering Group
8700 Monrovia, Suite 310
Lenexa, Kansas 66215

Jackson County
Sec 8 & 17 T 48 N , R 32 W

Dear Ms Biesma

This letter is in response to your request for hydrogeologic information at the above site in Jackson County

I have enclosed several items that will help in your assessment. The Geology of the Lees Summit Quadrangle, Jackson County, Missouri contains, in addition to the geologic map, a description of lithology, structure, engineering characteristics and other information. Groundwater Maps of Missouri should help document the poor groundwater resources of the area.

I enclosed photocopies of logs of 3 wells in the area surrounding the site. I looked for logs for sections 4, 5, 6, 7, 8, 9, 16, 17 and 18. The three I enclosed are the only insoluble residue logs in the file that show the geology from top to bottom. Several other logs were incomplete; they started at depths of more than 300 feet below surface, and contained no information on the shallow strata.

In general, this area is one of very poor groundwater resources. The upper 600 feet of strata consists of Pennsylvanian cyclothemic deposits of limestone, sandstone, and shale, with some minor coal seams. Permeabilities are mostly low in unfractured material. Groundwater contained in the Pennsylvanian units is mostly a sodium chloride type. Locally, shallow wells (generally less than 150 feet deep) may yield 1 to 3 gallons per minute of marginal quality water from the Pennsylvanian. This water usually does not meet minimum public drinking water standards, but was still used for farm and household water-supply before public water was available. Years ago, hand-dug wells 10 to 30 feet deep were often used. These were recharged by water in surficial materials. Though the very shallow water is generally less mineralized, this type of well is highly prone to bacterial contamination. Wells completely penetrating the Pennsylvanian may contain water with total dissolved solids of 10,000 to 20,000 mg/l total dissolved solids.

Mississippian and Ordovician strata in the area are also known to contain highly mineralized water with total dissolved solids of more than 30,000 mg/l. Jackson County is in the Forest City basin. Circulation in the aquifers is quite poor, allowing large amounts of material to be

(Biesma, P 2)

dissolved Deeper saline water is probably due to conate water Except for the very shallow Pennsylvanian units, there is no bedrock water that can be considered potable

The alluvial water resources in the area are much better than those of the bedrock The Missouri River alluvium in northern Jackson County is highly water-productive capable of yielding more than 1,000 gallons per minute to properly located and constructed gravel-pack wells The Little Blue River alluvium is also water productive, though its yield is probably considerably less than that of the Missouri River alluvium

No glacial drift is reported present in the area Loess covers some of the area but is not considered water-productive

I have also enclosed a list of publications, and photocopies from the 1917 Geology of Jackson County by W E McCourt This book is out of print, but we can loan a copy to you if necessary It is available on microfiche for the cost of reproduction I looked through it and did not see much I felt you would be interested in The stratigraphic information contained in Geology of the Lees Summit Quadrangle should be much better

Please keep in mind that any publication shown on the List of Publications is available by loan, microfiche or both If I can help further, please feel free to contact me

Sincerely,
Division of Geology and Land Survey



James E Vandike, Geologist III
Water Resources Research and Planning

JEV/me

enclosure

APPENDIX B

LIST OF RESIDENTS CONTACTED IN THE WELL SURVEY
NEAR THE ELLIOTT SHOOTING PARK SITE

STATE OF MISSOURI

HON JOHN M DALTON GOVERNOR
DEPARTMENT OF BUSINESS AND ADMINISTRATION

DIVISION OF
GEOLOGICAL SURVEY AND WATER RESOURCES
THOMAS R BEVERIDGE STATE GEOLOGIST

GROUNDWATER AREAS OF MISSOURI

BY ROBERT D KNIGHT

1962

EXPLANATION

PRODUCTION AREAS AND
AQUIFERS

1

GLACIAL DRIFT AND

2

PENNSYLVANIAN AND
LIMESTONES AND SHALES

Plate 1

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into SDMS due to its size or construction**

GROUNDWATER

90

STATE OF MISSOURI

HON JOHN M DALTON GOVERNOR
DEPARTMENT OF BUSINESS AND ADMINISTRATION

DIVISION OF
GEOLOGICAL SURVEY AND WATER RESOURCES
THOMAS R BEVERIDGE STATE GEOLOGIST

Plate 2

WATER QUALITY DEEP AQUIFERS IN MISSOURI

COMPILED BY DALE L FULLER

1962

EXPLANATION

LOCATION NUMBER
TOTAL DISSOLVED SOLIDS
CHLORIDES

1 22 24

1287 0

1903 1

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into SDMS due to its size or construction**